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Oleg JEFIMENKO

Electrostatic Motors

» **JEFIMENKO, Oleg : Electrostatic Motors** ~ PDF copy of the out-of-print classic. Run motors with atmospheric electricity.

***Popular Science* (April 1971)**

The Amazing Motor That Draws Power from the Air

by

C.P. Gilmore & William J. Hawkins

Would you believe an electric motor made almost entirely of plastic? That can run on power transmitted through open air? And sneak free electricity right out of the earth's electrical field?

At the University of West Virgina we saw a laboratory full of such exotic devices spinning, humming, and buzzing away like a swarm of bees. They are electrostatic motors, run by charges similar to those that make your hair stand on end when you comb it on a cold winter's day.

Today, we use electromagnetic motors almost exclusively. but electrostatics have a lot of overlooked advantages. They're far lighter per horsepower than electromagnetics, can run at extremely high speeds, and are incredibly simple and foolproof in construction.

"And, in principle," maintains Dr Oleg Jefimenko, "they can do anything electromagnetic motors can do, and some things they can do better."

Jewel-like Plastic Motors.

Jefimenko puts on an impressive demonstration. He showed us motors that run on the voltage developed when you hold them in your hands and scuff across a carpet, and other heavier, more powerful ones that could do real work. Up on the roof of the University's physics building in a blowing snowstorm, he connected an electrostatic motor to a specially designed earth-field antenna. It twirled merrily from electric power drawn out of thin air.

These remarkable machines are almost unknown today. Yet the world's electric motor was an electrostatic. It was invented in 1748 by Benjamin Franklin.

Franklin's motor took advantage of the fact that like charges repel, unlike ones attract. He rigged a wagon-wheel-sized, horizontally mounted device with 30 glass spokes. On the end of each spike was a brass thimble. Two oppositely charged leyden jars -- high voltage capacitors -- were so placed that the thimbles on the rotating spokes barely missed the knobs on the jars (see photo).

As a thimble passed close to a jar, a spark leaped from knob to thimble. That deposited a like charge on the thimble, so they repelled each other. then, as the thimble approached the oppositely charged jar, it was attracted. As it passed this second jar, a spark jumped again, depositing a new charge, and the whole repulsion-attraction cycle began again.

In 1870, the German physicist J.C. Poggendorff built a motor so simple it's hard to see what makes it work. The entire motor, as pictured here, is a plastic disk (Poggendorff used glass) and two electrodes. The electrodes set up what physicists call a corona discharge; their sharp edges ionize air molecules that come in contact with them. These charged particles floating through the air charge the surface of the palstic disk nearby. Then the attraction-repulsion routine that Franklin used takes place.

A few papers on electrostatic motors have trickled out of the laboratories in recent years. But nobody really showed much interest until Dr Jefimenko came on the scene.

The Russian-born physicist was attending a class at the University of Gottingen one day shortly after World War II when the lecturer, a Prof. R.W. Pohl, displayed two yard-square metal plates mounted on the end of a pole. He stuck the device outside and flipped it 180 degrees. A galvanometer hooked to the plates jumped sharply.

"I could never forget that demonstration," said Jefimenko. "And I wondered why, if there is electricity in the air, you couldn't use it light a bulb or something."

Electricity Everywhere

The earth's electrical field has been known for centruries. Lightning and St Elmo's fire are the most dramatic manifestations of atmospheric electricity. But the field doesn't exist just in the vicinity of these events; it's everywhere.

The earth is an electrical conductor. So is the ionosphere, the layer of ionized gas about 70 kilometers over our heads. The air between is a rather poor insulator. Some mechanisms not yet explained constantly pumps large quantitites of charged particles into the air. The charged particles cause the electrical field that Jefimenko saw demonstrated. Although it varies widely, strength of the field averages 120 volts per meter.

You can measure this voltage with an earth-field antenna -- a wire with a sharp point at the top to start a corona, or with a bit of radioactive materials that ionizes the air in its immediate vicinity. near the earth, voltage is proportional to altitude; on an average day you might measure 1200 volts with a 10-meter antennas.

Over that past few years, aided by graduate-student Henry Fischbach-Nazario, Jefimenko designed advanced corona motors. With David K. Walker, he experimented with electret motors. An electret is an insulator with a permanent electrostatic charge. It produces a permanent electrostatic charge in the surrounding space, just as a magnet produces a permanent magnetic field. And like a magnet, it can be used to build a motor.

Jefimenko chose the electrostatic motor for his project because the earth-field antennas develop extremely high-voltage low-current power -- and unlike the electromagnetic motor -- that's exactly what it needs.

The Climactic Experiment

On the night of Sept. 29, 1970, Jefimenko and Walker strolled into an empty parking lot, and hiked a 24-foot pole painted day-glow orange into the sky. On the pole's end was a bit of radioactive material in a capsule connected to a wire. The experimenters hooked an electret motor to the antenna, and, as Jefimenko describes it, "the energy of the earth's electrical field was converted into continuous mechanical motion."

Two months later, they successfully operated operated a corona motor from electricity in the air.

Any Future In It?

Whether the earth's electrical field will ever be an important source of power is open to question. There are millions -- perhaps billions -- of kilowatts of electrical energy flowing into the earth constantly. Jefimenko thinks that earth-field antennas could be built to extract viable amounts of it.

But whether or not we tap this energy source, the electrostatic motor could become important on its own.

* In space or aviation, it's extreme light weight could be crucial. Jefimenko estimates that corona motors could deliver one horsepower for each 3 pounds of weight.

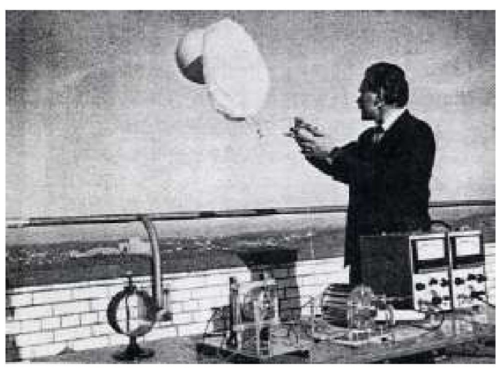
* They'd be valuable in laboratories where even the weakest magnetic field could upset an experiment.

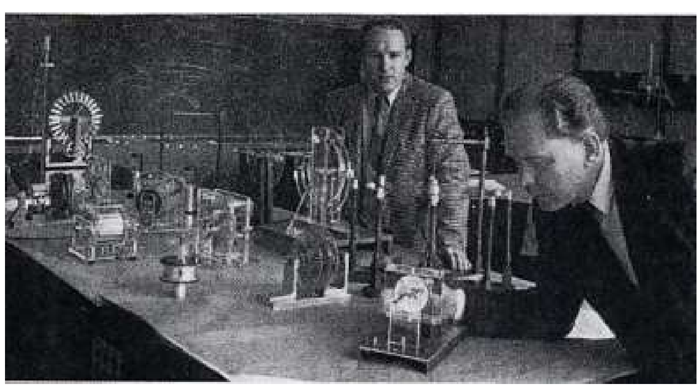
* Suspended on air bearings, they'd make good gyroscopes.

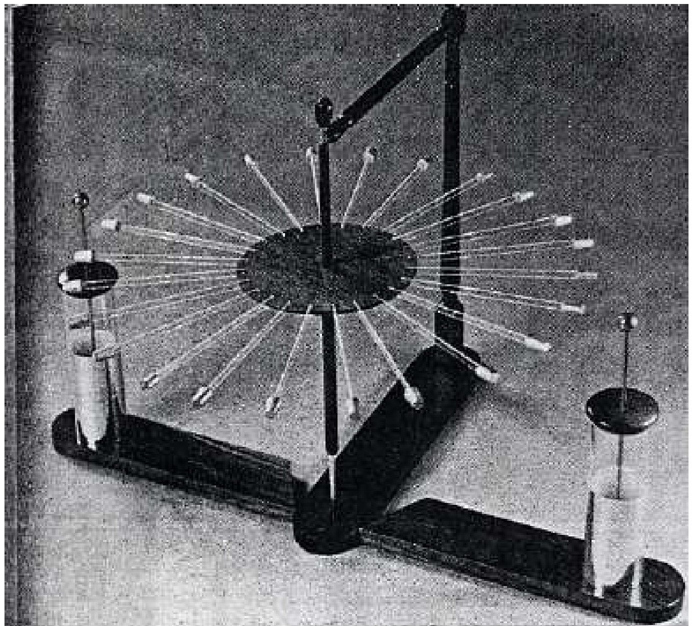
In a particularly spectacular experiment, Jefimenko turned on a Van de Graaff generator -- a device that creates a very-high-voltage field. About a yard away he placed a sharp-pointed corona antenna and connected it to an electrostatic motor. The rotor began to spin. The current was flowing from the generator through the air to where it was being picked up by the antenna.

The stunt had a serious purpose: The earth's field is greatest on mountaintops. Jefimenko would like to set up a large antenna in such a spot, then aim an ultraviolet laser beam at a receiving site miles away at ground level. The laser beam would ionize the air, creating an invisible conductor through apparently empty space.

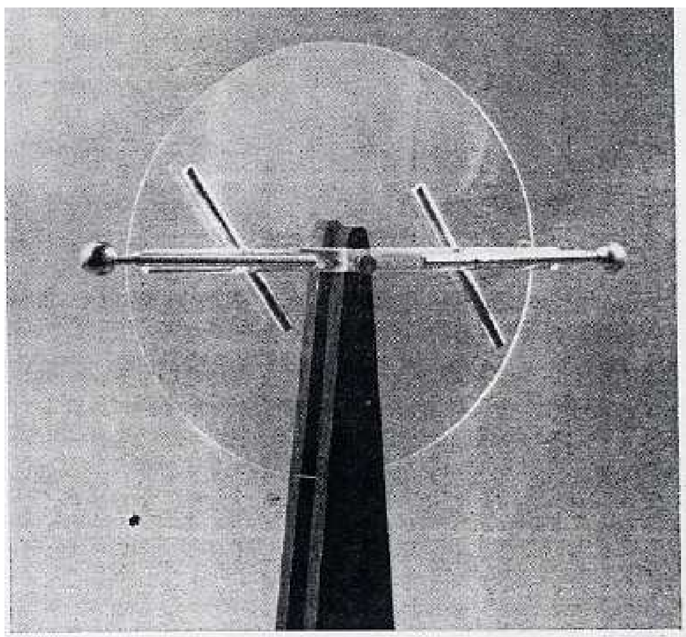
To be sure, many difficulties exist; and no one knows for sure whether we'll ever get useful amounts of power out of the air. But with thinking like that, Jefimenko's a hard man to ignore.



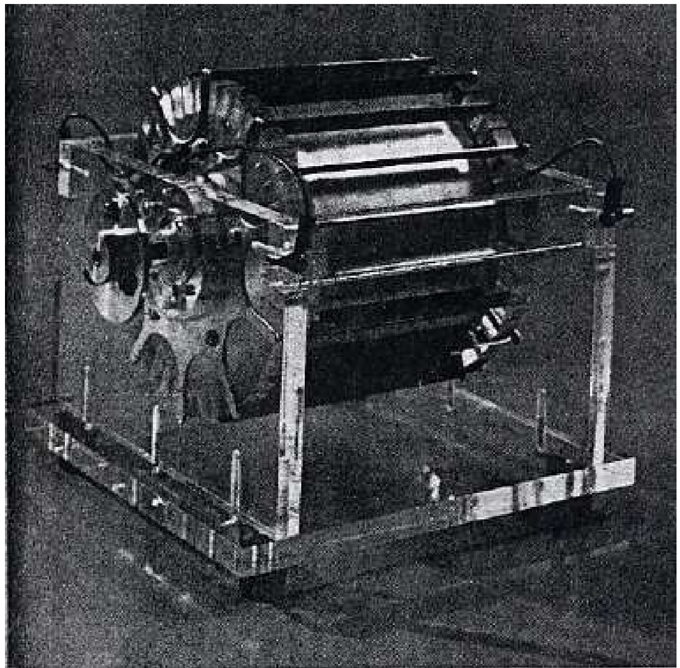




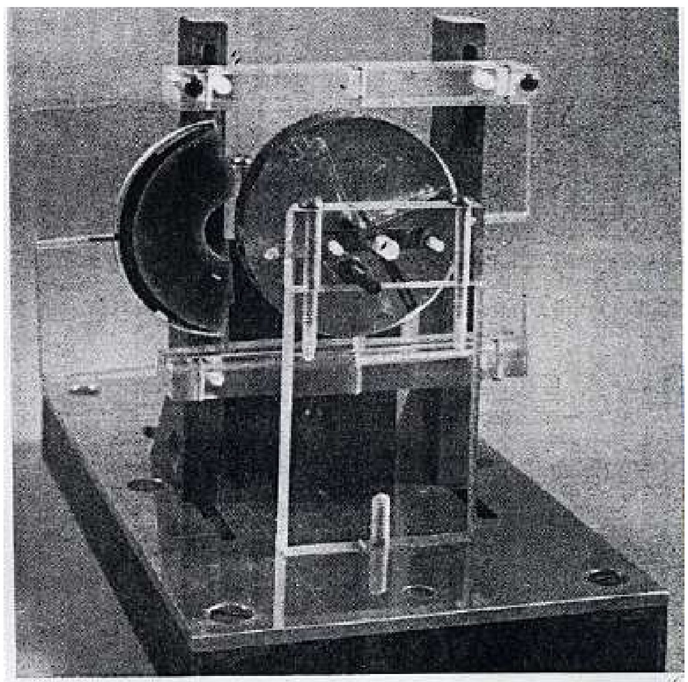
World's first electrostatic motor looked like this, according to Benjamin Franklin's description. Franklin said he'd use it to turn a roasting turkey, but there's no evidence that he did.



Simplest electrostatic motor ever designed was built by physicist J. C. Poggendorff. Two slanted electrodes spray charges onto disk, alternately repel and attract it to make it revolve.



Most efficient, most powerful electrostatic shown to date was designed by Dr. Oleg Jefimenko. It has multiple electrodes, cylindrical rotor, and develops a maximum of 70 watts of power.



Electret motor above turns on as little as 60 volts. It was the first to run on power from the earth's electrical field. Such motors can achieve extremely high speeds, and use little power

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***Popular Science* (May 1971)**

Electrostatic Motors You Can Build

by

C.P. Gilmore & William J. Hawkins

When we crank up the electrostatic motor at the top of this page, people always want to know what makes it run. It is mysterious -- there's nothing but a plastic disk and two strange electrodes. Yet there it is, spinning merrily.

In "The Amazing Motor That Draws Power From the Air", last month, we told about our visit to the laboratory of Dr Oleg Jefimenko at the University of West Virginia, who has designed and built a variety of these ingenious machines. now, as promised, we bring you details on how you can build your own electrostatic motor from simple materials.

The devices that you see here are corona-discharge motors. The sharp-pointed or knife-edge electrodes create a corona, which ionizes or charges the air particles floating by. These charged particles transfer their charge to the closest part of the plastic rotor and charge it up, just as you can charge your body by walking across a wool rug on a dry winter's day.

Once a spot on the rotor assumes a charge, it is repelled from the chargin electrode by electrostatic forces, and at the same time is attracted to the other electrode, which has an opposite charge. When the charged section of the rotor reaches the opposite electrode, another corona discharge reverses the polarity and starts the whole thing over again.

The Concept is Simple

And so are the motors. But that doesn't mean thery're easy to build. These motors run on millionths of a watt; they've got no power to waste turning stiff bearings or slightly misaligned rotors. So they must be built with watch-making precision.

They're made of acrylic sheet, rod, and tube stock -- Plexiglas and Lucite are two of the better-known brands. Acrylic cuts and works beautifully. Cut edges can be sanded so they have a white, frosted appearance that, in contrast with clear surfaces, gives your finished motor a sparkling, jewel-like appearance. If you like clear edges, you can buff them on a wheel and the whole thing becomes transparent.

Drill and tap the acrylic and assemble parts with machine screws. This allows for fine adjustment and alignment. Later, you can make the whole thing permanent by putting a little solvent along the joints. The solvent flows into the joint and fuses it permanently.

Details of framework, support and so on aren't important; change them if you like. but work with care if you want to avoid headaches. The Poggendorff motor looked simple; we slapped it together in a couple of hours, hooked up the power source -- and nothing happened. We gave it a few helpful spins by hand, but it wouldn't keep running.

The cure took about 3 hours. First, we noticed that the outer edge of the disk wobbled from side to side about 1/16 of an inch as the wheel revolved. So the rotor-electrode distance was constantly changing. There was a little play in the 1/4" hole we had drilled for the electrodes -- so they weren't lined up absolutely square with the disk. Then we noticed that the disk always stopped with one side down. The imbalance was only a fraction of an ounce -- but it was too much.

We drilled out the old hub and cemented in a new one -- this time, carefully. We lined up the electrodes -- precisely. Then, once more spinning the disk by hand, we added bit of masking tape until it was perfectly balanced. We connected the power -- and slowly... slowly... the disk began to turn. After about a minute, we clocked some turns with a watch and found it was spinning at 200 rpm. A moment later, we lost count. It was a great feeling.

Where Tolerances Are Brutal

We had even more trouble with the octagonal-window machine. When it wouldn't run and we turned the shaft by hand, we could feel the rotor dragging. We took it apart, felt all the surfaces on the rotor and the framework's insides and found a few bits of hardened cement, which we removed. We filed down all edges on the rotor adn the windows to make sure there were no beads or chips dragging.

The rotor and corner separators are made from the same sheet of 1/2" plastic, so rotor clearance is achieved by putting shims at the corners to hold the side plates slightly more than 1/2" apart. With the 1/16" shims we were using, we could see that the sides were slightly misaligned so the shaft was not being held at a true 90 degrees. We drilled slightly oversized holes in the corners of one side piece and carefully adjusted until the rotor was turning true in the slot. To give the motor more torque, we put a bead of cement along the outer edge of each aluminum-foil electrode to stop corona leakage. The motor ran.

Take A Giant Step

Once you've built these machines, why not design your own? Start with the Jefimenko 1/10 hp model (pictured) as a challenge. Then plan one from scratch. You can power your motors with a laboratory high-voltage supply, a Van de Graff

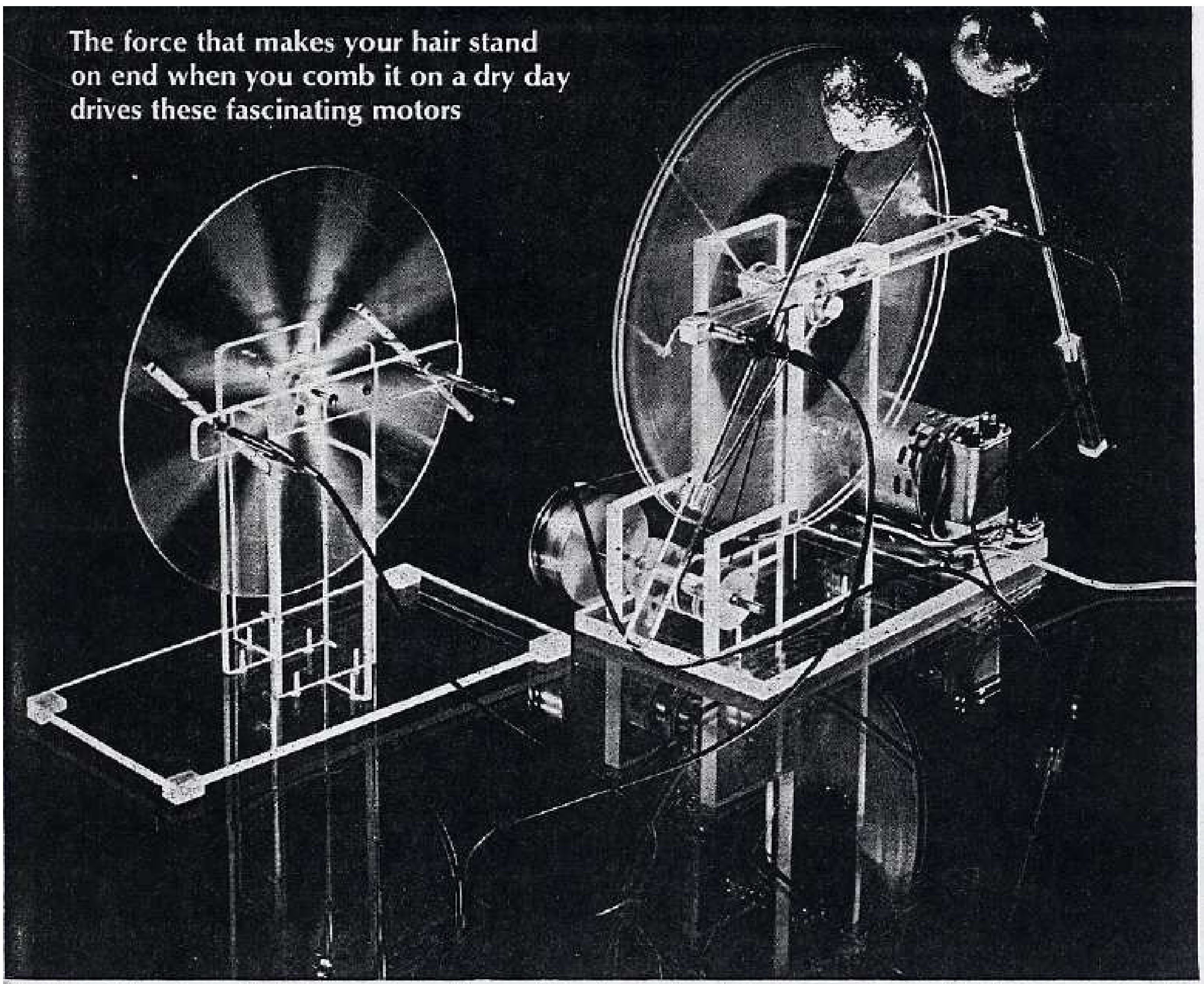
generator, or a Wimhurst machine or any other high-voltage source. We've been running ours on the home-built Wimhurst machine shown in the photos. (If you don't want to build one, Wimhurst machiens are available from scientific supply houses such as Edmund Scientific).

The discharge globes are traditional for high-voltage machines. They aren't necessary, but they give a quick check on machine operation and a satifying arc when you move them within 1/2" of each other. Incidentally, that funny smell is ozone. But its concentration is too low to be harmful. The generator is safe, too. You can hold both electrodes in your hands and all you'll feel is a tingle. This particular generator, we estimate, puts out about 30,000 volts.

To make wiring simple, we used standard connectors on the Wimhurst collectors, and meter leads with regular banana plugs and alligator clips to hook up the motors.

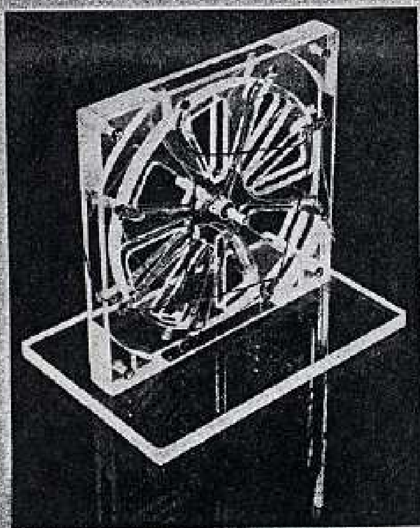
Last month, we mentioned seeing Dr Jefimenko run his electrostatic motors on electricity tapped from the earth's field. We haven't had a chance to try this yet with ours, but it should work. If you want to try, you'll need a needle-pointed piece of music wire a few inches long to start a corona, plus several hundred feet of fine copper wire.

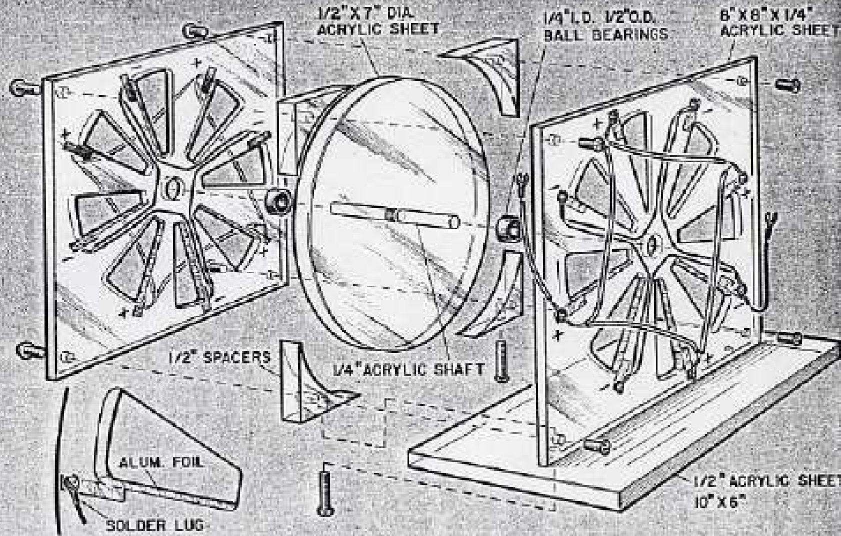
Connect the pointed wire to the fine conductor, get the sharp point up into the air at least 200-300 feet with a kite or balloon, and hook the wire to one side of the motor. Hook the other side of the motor to ground. The earth field antenna should at times be able to develop up to 20,000 volts from the earth's electrical field. If nothing happens, check your equipment, or try another day. The field changes constantly.



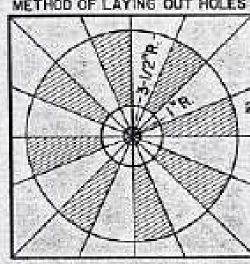
The electrostatic motor on the left turns between three- and four-hundred rpm when connected to the Wimshurst generator at right.

This octagonal-window design makes motor handsome, self-starting

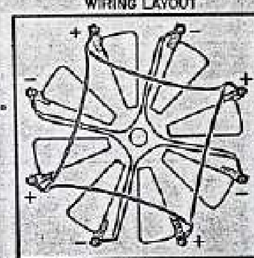




METHOD OF LAYING OUT HOLES

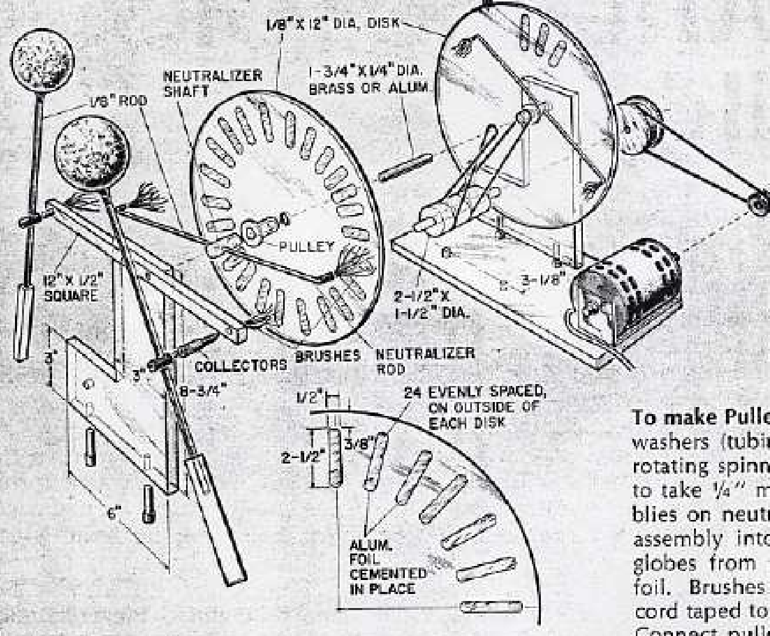


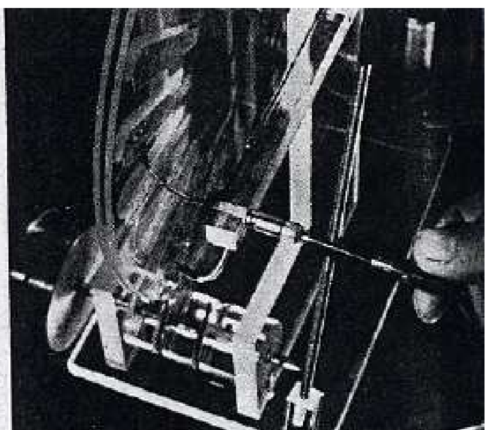
WIRING LAYOUT



Rotor of the Jefimenko-designed motor shown here is a ½″ plastic disk with a ¼″ shaft cemented carefully in place. Clamp the two outer sheets together before you drill the bearing holes and cut the windows. Aluminum foil electrodes can be cut to approximate shape, glued in place, and trimmed with razor blade. Keep + and − wiring separated by ½″ to avoid arcing. Note that electrodes oppose each other directly; opposing electrodes are of opposite polarity. Cement corner separators to one side for stability, attach other side with screws. To assemble, shim sides apart. Shim thickness of ¹⁄₁₆″ or less is best if rotor can be made to turn freely within this narrow gap. Avoid sharp corners, points, or edges in electrical circuits. They develop corona and leak power into air.

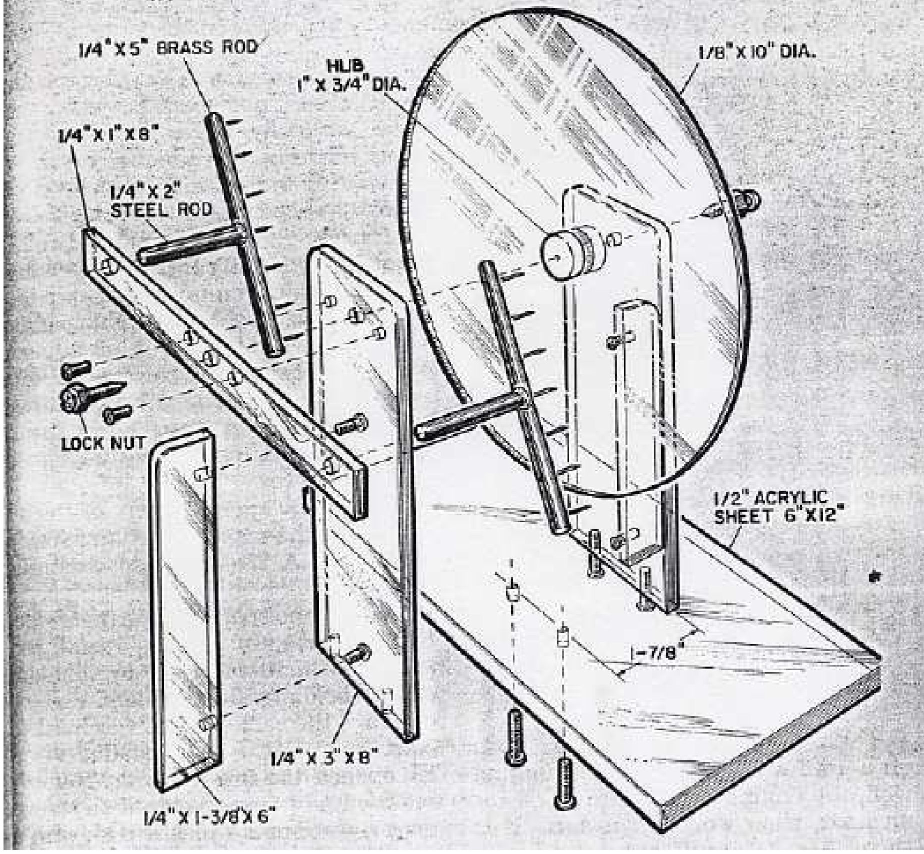
Wimshurst machine generates 30,000 volts



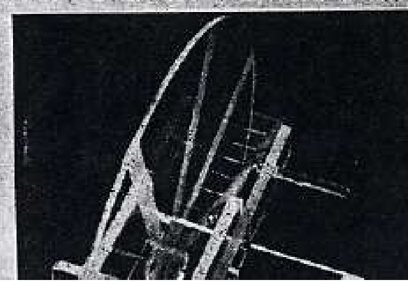


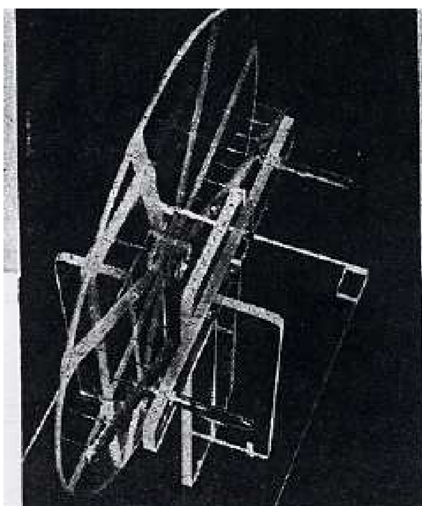
To make Pulleys, drill rotors, cement in ½″ i.d. tubing plus plastic washers (tubing protrudes ¹⁄₁₆″ on inner surface to hold counter-rotating spinning disks ⅛″ apart). Drill ½″ o.d. neutralizer shafts to take ¼″ metal shaft; assemble by slipping rotor-pulley assemblies on neutralizer shafts, neutralizer shafts on metal shaft. Slip assembly into ¼″-deep holes drilled in supports. Make spark globes from polystyrene Christmas balls wrapped in aluminum foil. Brushes must be flexible; use aluminum-braided gift-wrap cord taped to rods. Use any drive that turns disks about 1,200 rpm. Connect pulleys with tape-recorder drive belts.

Best first project: motor designed by physicist J. C. Poggendorff in 1870

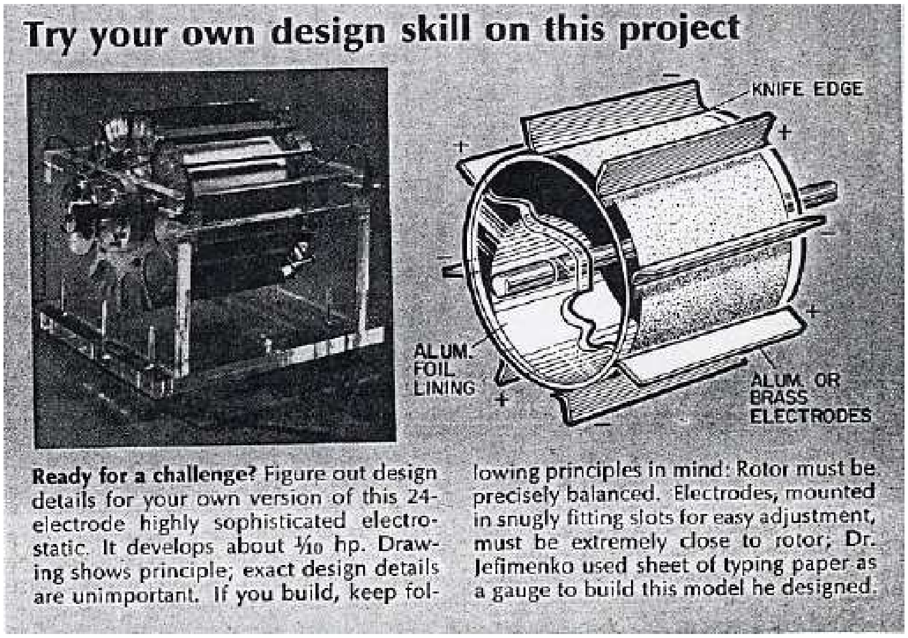


To build Poggendorff motor, drill center of the rotor disk accurately, cement ¾" hub in place, use centerpunch to make bearing indentations in the ends of the hub. Center gap between needle bearings must be adjustable; easiest way is to make bearings from machine screws sharpened on grindstone. Use locknuts to hold fine adjustment. For electrodes, drill seven equidistant holes in brass, steel, or aluminum rods; sharpen brads to a needle point, press-fit them into the holes, grind off heads flush. Brads should protrude about ½". File flat on the back of electrodes, solder or drill, tap, and thread support at right angles. Get extra torque if desired by adding an extra set of electrodes on the opposite side of rotor.





Mounting, with rotor removed, shows the relative positions of supports, needle bearings, and electrodes. Electrode points should be close to disk, but not touching.



Try your own design skill on this project

Ready for a challenge? Figure out design details for your own version of this 24-electrode highly sophisticated electrostatic. It develops about 1/10 hp. Drawing shows principle; exact design details are unimportant. If you build, keep following principles in mind: Rotor must be precisely balanced. Electrodes, mounted in snugly fitting slots for easy adjustment, must be extremely close to rotor; Dr. Jefimenko used sheet of typing paper as a gauge to build this model he designed.

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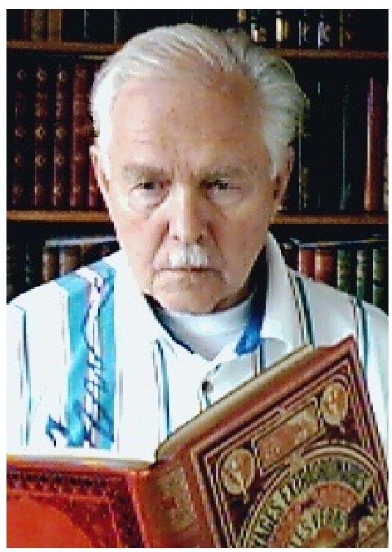
http://en.wikipedia.org/wiki/Oleg_D._Jefimenko

Oleg D. Jefimenko



(October 14, 1922, Kharkiv, Ukraine - May 14, 2009, Morgantown, West Virginia, USA) - physicist and Professor Emeritus at West Virginia University.

Biography

Jefimenko received his B.A. at Lewis and Clark College (1952). He received his M. A. at the University of Oregon (1954). He received his Ph.D. at the University of Oregon (1956). Jefimenko has worked for the development of the theory of electromagnetic retardation and relativity. In 1956, he was awarded the Sigma Xi Prize. In 1971 and 1973, he won awards in the AAPT Apparatus Competition. Jefimenko has constructed and operated electrostatic generators run by atmospheric electricity.

Jefimenko has worked on the generalization of Newton's gravitational theory to time-dependent systems. In his opinion, there is no objective reason for abandoning Newton's force-field gravitational theory (in favor of a metric gravitational theory). He is actively trying to develop and expand Newton's theory, making it compatible with the principle of causality and making it applicable to time-dependent gravitational interactions.

Jefimenko's expansion, or generalization, is based on the existence of the second gravitational force field, the "cogravitational, or Heaviside's, field". This is might also be called a gravimagnetic field. It represents a physical approach profoundly different from the time-space geometry approach of the Einstein general theory of relativity. Oliver Heaviside first predicted this field in the article "A Gravitational and Electromagnetic Analogy" (1893).

Selected publications

Books

* "Electrostatic motors; their history, types, and principles of operation". Star City [W. Va.], Electret Scientific Co. [1973]. LCCN 73180890
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* "Electricity and Magnetism: An Introduction to the Theory of Electric and Magnetic Fields", 2nd ed., Electret Scientific, Star City, 1989.
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* "A neglected topic in relativistic electrodynamics: transformation of electromagnetic integrals". arxiv.org, 2005.
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* "How can An Electroscope be Charged This Way?", TPT 56, 1979.
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* "Effect of the earth's magnetic field on the motion of an artificial satellite," Am. J. Phys. 27, 344-348, 1959.

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* "'Maxwell's Equations'", Macmillan Encyclopedia of Physics, Macmillan, New York, 1996.

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http://www.integrityresearchinstitute.org/FutureEnergy/FutureEnergyTech.html

The next energy breakthrough is Dr. Oleg Jefimenko's electrostatic motors. Discovered by Ben Franklin in the 18th century, electrostatic motors are an all-American invention. They are based on the physics of the fair-weather atmosphere that has an abundance of positive electric charges up to an altitude of 20 km. However, the greatest concentration is near the ground and diminishes with altitude rapidly. Dr. Jefimenko discovered that when sharp-pointed antennas are designed for a sufficient length to obtain at least 6000 volts of threshold energy, the fair-weather current density available is about a picoampere per square meter. Such antennas produce about a microampere of current. However, small radioactive source antennas may be used instead that have no threshold voltage and therefore no height requirements. Similar to a nuclear battery design of Dr. Brown, these antennas have larger current potentials depending upon the radioactive source used (alpha or beta source) and ionize the air in the vicinity of the antenna. Electrostatic motors are lighter than electromagnetic motors for the same output power since the motor occupies the entire volume. For example, it is expected that a motor one meter on a side will provide a power of one megawatt and weigh 500 kg or less. Electrostatic motors also require very little metal in their construction and can use mostly plastic for example. They can also operate from a variety of sources and range of voltages. As Dr. Jefimenko points out, "It is clear that electrostatic motor research still constitutes an essentially unexplored area of physics and engineering, and that electrostatic motor research must be considered a potentially highly rewarding area among the many energy-related research endeavors."[5] The atmospheric potential of the planet is not less than 200,000 megawatts. He has succeeded in constructing demonstration motors that run continuously off atmospheric electricity. Jefimenko's largest output motor was an electret design that had a 0.1 Hp rating. [6] Certainly the potential for improvement and power upgrade exists with this free energy machine.

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http://forum.allaboutcircuits.com/newsgroups/viewtopic.php?t=67792

Book Report

So I go out on my step and what to my wondering eyes doth appear but the box from Amazon.com containing the Jefimenko books that Bill Miller shamed me into finally buying. So I take a quick look inside and decide to give an initial report here. (Too much vector math in there for a thorough review.)

These books have some amazing advanced thinking in the understanding of Maxwell and EM. One first thought is the consideration of causality. This is typically totally ignored in the EM community. Evidence of that is the fact that EM waves are widely held to be propagated by the E field creating the H field and the H field creating the E field as it goes along. Too bad it's just not true! Jefimenko points out that causality demands that that an event must be PRECEDED by it's cause! Simultaneous events CANNOT be "causal" of each other. Hence E and H fields of waves are created by the WAVE SOURCE not each other! Same things goes for the E field created by Faraday induction. It simply cannot be "caused" by the time-varying Magnetic Field. "Magnetic induction" is therefore a misnomer. Such induction is caused by the source CURRENT and NOT the magnetic field!

This leads Jefimenko on to note that contrary to the "one E field" theory that has been believed for so many years, the inductive E field is clearly NOT the same field as an electrostatic E field. Jefimenko terms this inductive E field the "Electrokinetic Field" to show that it is a different field from the electrostatic E field. Very good. However, old habits die hard and even Jefimenko persists in writing an expression for a "total E field" following Maxwell as consisting of a sum of the electrostatic and electrokinetic parts as if they were both the "same" kind of E field.

Jefimenko then proceeds to illustrate the electrokinetic fields with a series of calculations and examples using his formulas as an approach. He presents it as basically a "new" way of doing this and in one sense it is compared to the commonly used and non-causal bogus "flux linkage" methods. However, he fails to note that the causal Neumann formula is in essence identical to his formulation and has been a standard formulation for years for the calculation of the "electrokinetic field" or what is usually termed "mutual induction". Nevertheless his example calculations are important basic references to the topic of Faraday induction. And the consideration of causality clearly shows that the Neumann approach has the edge over the "flux linkage" ideas with at times fail to give correct results.

But the subject doesn't end with induction, he pulls gravity into the mix. Of particular interest is that he shows that once you introduce causality into Newton's theory of gravitation, interesting things start to happen! Relativity suddenly begins to show up and even more interesting "action-reaction" is soon discovered to actually be a law that does NOT hold in all cases! The electromagnetic nature of gravity quickly becomes strongly hinted at and without action-reaction laws, those dreamed of devices such as anti-gravity ships and the "force-glove" that you wear to push over a building become theoretical possibilities! These are truly books full of thought-provoking new ways of looking at tired old physics!

I'm not going to be going through the large quantity of field theory math in these books in a hurry, but that's OK because clearly taking the time to go through in detail WILL be worth the effort! What can I say? Listen to Bill Miller and get that

order off to Amazon.com now. At roughly $25 each these two books are a huge bargain to the usual EM text books costing hundreds of dollars and then being full of bogus ideas and misunderstandings of the established theories. Just do it! I did and I'm not sorry I did!

Benj

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http://stupac2.blogspot.com/2007/04/bizarre-and-intriguing-story-of-oleg.html

The Bizarre and Intriguing Story of Oleg Jefimenko and the Solutions to Maxwell's Equations

I recently heard the story of Oleg Jefimenko during a lecture on Electrodynamics, specifically the general solution to Maxwell's Equations.

Jefimenko's tiny bit of fame comes from Jefimenko's Equations, which are the general solution to Maxwell's equations expressed solely in terms of sources, that is charge and current distributions. The equations are messy and difficult to work with, and aren't used much in practice. But they do reveal certain bits of physics (such as the applicability of the quasistatic approximation (the link goes to a thermodynamics page, but the idea is the same) and that fields must be created by sources), and it's always nice to have the general solution to a problem available.

These equations weren't written down until 1966, about a century after Maxwell's Equations were known. Some people will claim (as the Wikipedia article cited does) that Jefimenko's Equations were written down earlier, but those earlier versions are always slightly different and not quite complete. What's really funny is that Jefimenko wrote them down in an attempt to formulate an alternative to Maxwell's equations.

When my current Professor, David Griffiths, was in the process of writing a paper on the subject, he independently derived Jefimenko's equations, and tried to figure out if anyone had done it before. Other than some slightly tricky and annoying math, they're not hard to derive, so someone must have done it. He found that Jefimenko had written them in a book that was published by a company that had only published one other work, also by Jefimenko (apparently regular publishers wouldn't take his books, so he went to a prestige press). He contacted Jefimenko, and Jefimenko didn't believe that he had solved Maxwell's equations, but that he had created an electromagnetic theory separate from (and doubtless better than) Maxwell's. Of course he had done no such thing, his formulation is exactly equivalent to Maxwell's, but he wasn't buying it.

According to Griffiths, Jefimenko currently submits one or two papers a week to American journals, gets denied, then publishes them in Europe (where review is apparently not as stringent). I don't know what they're about, the Wikipedia article says he focuses on overthrowing Einstein's General Relativity and Maxwell.

I found this story behind some esoteric equations to be pretty amusing, and thought others might agree. I hope you've enjoyed the convoluted and intriguing story behind Jefimenko's equations.

[Most of my information comes from a lecture with Griffiths, and as such could not be found online. Anything that is available online has been referenced.]

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http://electretscientific.com/

Electret Scientific Co
P.O. Box 4132
Star City, WV 26504 USA

Books by Professor Oleg Jefimenko

(also available from www.Amazon.com)

Gravitation and Cogravitation -- Developing Newton's Theory of Gravitation to its Physical and Mathematical Conclusion,
Paperback - List Price US$ 22.00
Hardback - List Price US$ 32.00

Electrostatic Experiments -- An Encyclopedia of Early Electrostatic Experiments, Demonstrations, Devices, and Apparatus,
by G.W. Francis (author), Oleg Jefimenko (editor)
Paperback - List Price US$ 24.00
Hardback - List Price US$ 48.00

Electromagnetic Retardation and Theory of Relativity -- New Chapters in the Classical Theory of Fields, 2nd edition,
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Causality, Electromagnetic Induction, and Gravitation -- A Different approach to the Theory of Electromagnetic and Gravitational Fields, 2nd edition,
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An Introduction to the Theory of Electric and Magnetic Fields, 2nd edition,
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http://www.amazon.com/Electrostatic-Motors-Oleg-D-Jefimenko/dp/0917406028

Electrostatic Motors (Paperback)
by Oleg D. Jefimenko

***Scientific American* (October, 1974)**

Electrostatic Motors Are Powered by Electric Field of the Earth

by

C. L. Strong

Although no one can make a perpetual motion machine, anyone can tap the earth's electric field to run a homemade motor perpetually. The field exists in the atmosphere between the earth's surface and the ionosphere as an electric potential of about 360,000 volts. Estimates of the stored energy range from a million kilowatts to a billion kilowatts.

Energy in this form cannot be drawn on directly for driving ordinary electric motors. Such motors develop mechanical force through the interaction of magnetic fields that are generated with high electric current at low voltage, as Michael Faraday demonstrated in 1821. The earth's field provides relatively low direct current at high voltage, which is ideal for operating electrostatic motors similar in principle to the machine invented by Benjamin Franklin in 1748.

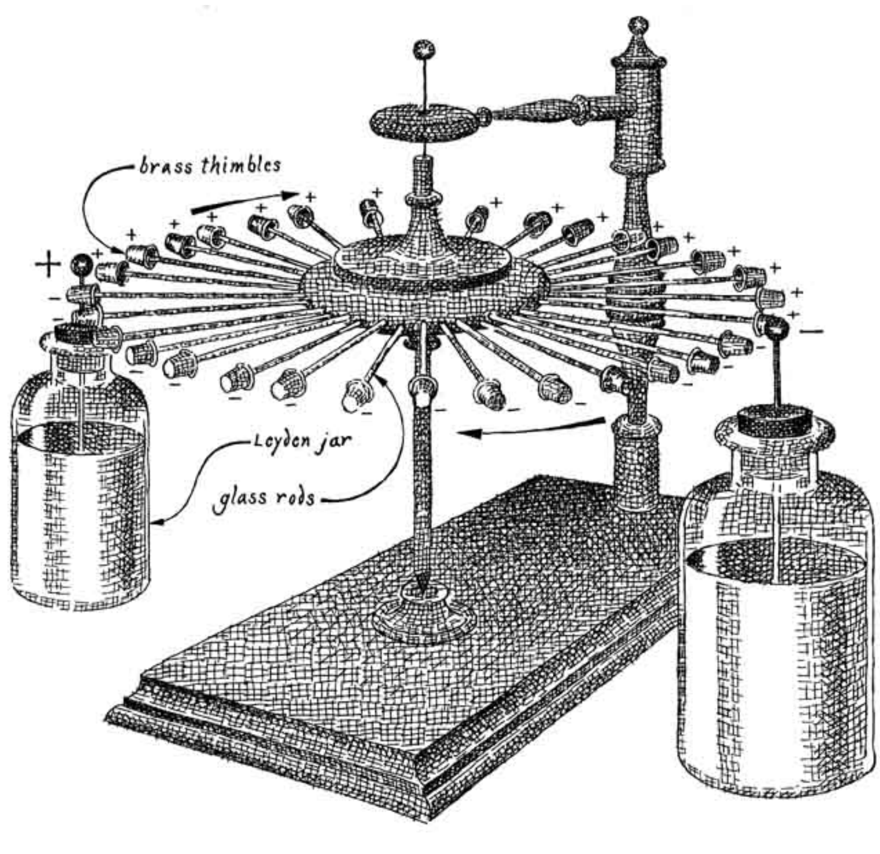
Motors of this type are based on the force of mutual attraction between unlike electric charges and the mutual repulsion of like charges. The energy of the field can be tapped with a simple antenna in the form of a vertical wire that carries one sharp point or more at its upper end. During fair weather the antenna will pick up potential at the rate of about 100 volts for each meter of height between the points and the earth's surface up to a few hundred feet. At higher altitudes the rate decreases. During local thunderstorms the pickup can amount to thousands of volts per foot. A meteorological hypothesis is that the field is maintained largely by thunderstorms, which pump electrons out of the air and inject them into the earth

through bolts of lightning that continuously strike the surface at an average rate of 200 strokes per second.

Why not tap the field to supplement conventional energy resources? Several limitations must first be overcome. For example, a single sharp point can draw electric current from the surrounding air at a rate of only about a millionth of an ampere. An antenna consisting of a single point at the top of a 60-foot wire could be expected to deliver about a microampere at 2,000 volts; the rate is equivalent to .002 watt. A point-studded balloon tethered by a wire at an altitude of 75 meters might be expected to deliver .075 watt. A serious limitation appears as the altitude of the antenna exceeds about 200 meters. The correspondingly higher voltages become difficult to confine.

At an altitude of 200 meters the antenna should pick up some 20,000 volts. Air conducts reasonably well at that potential. Although nature provides effective magnetic materials in substances such as iron, nickel and cobalt, which explains why the electric-power industry developed around Faraday's magnetic dynamo, no comparably effective insulating substances exist for isolating the high voltages that would be required for electrostatic machines of comparable power. Even so, electrostatic motors, which are far simpler to build than electromagnetic ones, may find applications in special environments such as those from which magnetism must be excluded or in providing low power to apparatus at remote, unmanned stations by tapping the earth's field.

Apart from possible applications electrostatic motors make fascinating playthings. They have been studied extensively in recent years by Oleg D. Jefimenko and his graduate students at West Virginia University. The group has reconstructed models of Franklin's motors and developed advanced electrostatic machines of other types.



Although Franklin left no drawing of his motor, his description of it in a letter to Peter Collinson, a Fellow of the Royal Society, enabled Jefimenko to reconstruct a working model [see illustration at right]. Essentially the machine consists of a rimless wheel that turns in the horizontal plane on low-friction bearings. Each spoke of the "electric wheel," as Franklin called the machine, consists of a glass rod with a brass thimble at its tip. An electrostatic charge for driving the motor was stored in Leyden jars. A Leyden jar is a primitive form of the modern high-voltage capacitor. Franklin charged his jars with an electrostatic generator.

The high-voltage terminals of two or more Leyden jars that carried charges of opposite polarity were positioned to graze the thimbles on opposite sides of the rotating wheel. The motor was started by hand. Thereafter a spark would jump from the high-voltage terminal to each passing thimble and impart to it a charge of the same polarity as that of the terminal. The force of repulsion between the like charges imparted momentum to the wheel.

Conversely, the thimbles were attracted by the oppositely charged electrode of the Leyden jar Franklin placed on the

opposite side of the wheel. As the thimbles grazed that jar, a spark would again transfer charge, which was of opposite polarity. Thus the thimbles were simultaneously pushed and pulled by the high-voltage terminals exactly as was needed to accelerate the wheel.

Franklin was not altogether happy with his motor. The reason was that running it required, in his words, "a foreign force, to wit, that of the bottles." He made a second version of the machine without Leyden jars.

In this design the rotor consisted principally of a 17-inch disk of glass mounted to rotate in the horizontal plane on low-friction bearings. Both surfaces of the disk were coated with a film of gold, except for a boundary around the edge. The rotor was thus constructed much like a modern flat-plate capacitor.

Twelve evenly spaced metal spheres, cemented to the edge of the disk, were connected alternately to the top and bottom gold films. Twelve stationary thimbles supported by insulating columns were spaced around the disk to graze the rotating metal spheres. When Franklin placed opposite charges on the top and bottom films and gave the rotor a push, the machine ran just as well as his first design, and for the same reason. According to Franklin, this machine would make up to 50 turns a minute and would run for 30 minutes on a single charge.

Jefimenko gives both motors an initial charge from a 20,000-volt generator. They consume current at the rate of about a millionth of an ampere when they are running at full speed. The rate is equivalent to .02 watt, which is the power required to lift a 20-gram weight 10 centimeters (or an ounce 2.9 inches) in one second.

Jefimenko wondered if Franklin's motor could be made more powerful. As Jefimenko explains, the force can be increased by adding both moving and fixed electrodes. This stratagem is limited by the available space. If the electrodes are spaced too close, sparks tend to jump from electrode to electrode around the rotor, thereby in effect short-circuiting the machine. Alternatively the rotor could be made cylindrical to carry electrodes in the form of long strips or plates. This scheme could perhaps increase the output power by a factor of 1,000.

Reviewing the history of electrostatic machines, Jefimenko came across a paper published in 1870 by Johann Christoff Poggendorff, a German physicist. It described an electrostatic motor fitted with a rotor that carried no electrodes. The machine consisted of an uncoated disk of glass that rotated in the vertical plane on low-friction bearings between opposing crosses of ebonite. Each insulating arm of the crosses supported a comblike row of sharp needle points that grazed the glass.

When opposing combs on opposite sides of the glass were charged in opposite polarity to potentials in excess of 2,000 volts, air in the vicinity of the points on both sides of the glass was ionized. A bluish glow surrounded the points, which emitted a faint hissing sound. The effect, which is variously known as St. Elmo's fire and corona discharge, deposited static charges on both sides of the rotor.

Almost the entire surface of the glass acquired a coating of either positive or negative fixed charges, depending on the polarity of the combs. The forces of repulsion and attraction between glass so charged and the combs were substantially larger than they were in Franklin's charged thimbles. The forces were also steadier, because in effect the distances between the combs and the charged areas remained constant. It should be noted that adjacent combs on the same side of the glass carried charges of opposite polarity, so that the resulting forces of attraction and repulsion acted in unison to impart momentum to the disk, as they did in Franklin's motor.

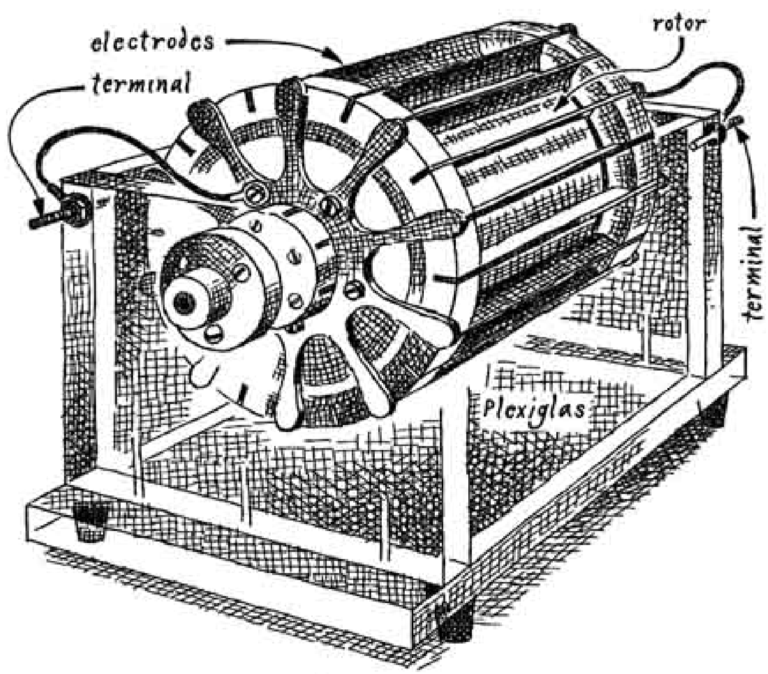
By continued experimentation Poggendorff learned that he should slant the teeth of the combs to spray charge on the glass at an angle. The resulting asymmetrical force made the motor self-starting and unidirectional. When the teeth were perpendicular to the glass surface, the forces were symmetrical, as they were in Franklin's motor. When the machine was started by hand, it ran equally well in either direction.

Poggendorff was immensely pleased by the rate at which his machine converted charge into mechanical motion. He concluded his paper with a faintly odious reference to Franklin's device. "That such a quantity of electricity must produce a far greater force than that in the [Franklin] electric roasting spit," he wrote, "is perfectly obvious and nowadays would not be denied by Franklin himself. With one grain of gunpowder one cannot achieve so much as with one hundred pounds."

Electrostatic motors are now classified in general by the method by which charge is either stored in the machine or transferred to the rotor. Poggendorff's machine belongs to the corona type, which has attracted the most attention in recent years. Although its measured efficiency is better than 50 percent, Poggendorff regarded it merely as an apparatus for investigating electrical phenomena. He wrote that "it would be a sanguine hope if one wanted to believe that any useful mechanical effect could be achieved with it."

Poggendorff's negative attitude toward the usefulness of his design may well have retarded its subsequent development. A modern version of the machine constructed in Jefimenko's laboratory has an output of approximately .1 horsepower. It operates at speeds of up to 12,000 revolutions per minute at an efficiency of substantially more than 50 percent. In one form the modern corona motor consists of a plastic cylinder that turns on an axial shaft inside a concentric set of knife-edge electrodes that spray charge on the surface of the cylinder [see illustration at left]. Forces that act between the sprayed charges and the knife-edge electrodes impart momentum to the cylinder.

Machines of this kind can be made of almost any inexpensive dielectric materials, including plastics, wood and even cardboard. The only essential metal parts are the electrodes and their interconnecting leads. Even they can be contrived of metallic foil backed by any stiff dielectric. The shaft can be made of plastic that turns in air bearings. By resorting to such stratagems experimenters can devise motors that are extremely light in proportion to their power output. Corona motors require no brushes or commutators. A potential of at least 2,000 volts, however, is essential for initiating corona discharge at the knife-edges.



A smaller and simpler version of the machine was demonstrated in 1961 by J. D. N. Van Wyck and G. J. Kühn in South Africa. This motor consisted of a plastic disk about three millimeters thick and 40 millimeters in diameter supported in the horizontal plane by a slender shaft that turned in jeweled bearings. Six radially directed needle points grazed the rim of the disk at equal intervals. When the machine operated from a source of from 8,000 to 13,000 volts, rotational speeds of up to 12,000 revolutions per minute were measured.

I made a corona motor with Plexiglas tubing two inches in diameter and one and a half inches long. It employed stiffbacked single-edge razor blades as electrodes. The bore of the tube was lined with a strip of aluminum foil, a stratagem devised in Jefimenko's laboratory to increase the voltage gradient in the vicinity of the electrodes and thus to increase the amount of charge that can be deposited on the surface of the cylinder. I coated all surfaces of the razor blades except the cutting edges and all interconnecting wiring with "anticorona dope," a cementlike liquid that dries to form a dielectric substance that reduces the loss of energy through corona discharges in nonproductive portions of the circuit.

The axial shaft that supports the cylinder on pivot bearings was cut out of a steel knitting needle. The ends of the shaft were ground and polished to 30degree points. To form the points I chucked the shaft in an electric hand drill, ground the metal against an oilstone and polished the resulting pivots against a wood lap coated with tripoli.

The bearings that supported the pivots were salvaged from the escapement mechanism of a discarded alarm clock. A pair of indented setscrews could be substituted for the clock bearings. The supporting frame was made of quarter-inch Lucite. The motor can be made self-starting and unidirectional by slanting the knife-edges. Those who build the machine may discover, as I did, that the most difficult part of the project, balancing the rotor, is encountered after assembly. The rotor must be balanced both statically and dynamically.

Static balance was achieved by experimentally adding small bits of adhesive tape to the inner surface of the aluminum foil that lines the cylinder until the rotor remained stationary at all positions to which it was set by hand. When the rotor was balanced and power was applied, the motor immediately came up to speed, but it shook violently. I had corrected the imbalance caused by a lump of cement at one end of the rotor by adding a counterweight on the opposite side at the opposite end of the cylinder. Centrifugal forces at the ends were 180 degrees out of phase, thus constituting a couple.

The dynamic balancing, which is achieved largely by cut-and-try methods, took about as much time as the remainder of the construction. To check for dynamic balance suspend the motor freely with a string, run it at low speed and judge by the wiggle where a counterweight must be added. Adhesive tape makes a convenient counterweight material because it can be both applied and shifted easily.

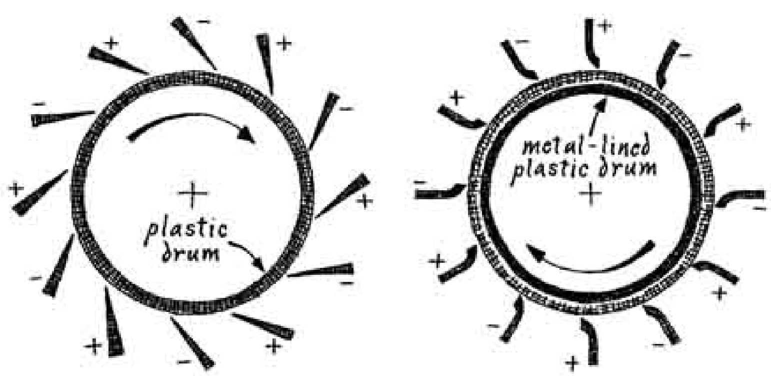
I made the motor as light and frictionless as possible with the objective of operating it with energy from the earth's field. The field was tapped with an antenna consisting of 300 feet of No. 28 gauge stranded wire insulated with plastic. It is the kind of wire normally employed for interconnecting electronic components and is available from dealers in radio supplies.

The upper end of the wire was connected to a 20-foot length of metallic tinsel of the kind that serves for decorating a Christmas tree. The tinsel functioned as multiple needle points. Strips cut from window screening would doubtless work equally well.

The upper end of the tinsel was hoisted aloft by a cluster of three weather balloons. Such balloons, each three feet in diameter, and the helium to inflate them are available from the Edmund Scientific Co. (300 Edscorp Building, Barrington, N.J. 08007). The weight in pounds that a helium-filled balloon of spherical shape can lift is roughly equal to a quarter of the cube of its radius in feet. To my delight the motor began to run slowly when the tinsel reached an altitude of about 100 feet. At 300 feet the rotor made between 500 and 700 revolutions per minute.

A note of warning is appropriate at this point. Although a 300-foot vertical antenna can be handled safely in fair weather, it can pick up a lethal charge during thunderstorms. Franklin was incredibly lucky to have survived his celebrated kite experiment. A European investigator who tried to duplicate Franklin's observations was killed by a bolt of lightning. The 300-foot antenna wire can hold enough charge to give a substantial jolt, even during fair weather. Always ground the lower end of the wire when it is not supplying a load, such as the motor.

To run the motor connect the antenna to one set of electrodes and ground the other set. Do not connect the antenna to an insulated object of substantial size, such as an automobile. A hazardous charge can accumulate. Never fly the balloon in a city or in any other location where the antenna can drift into contact with a high-voltage power line. Never fly it below clouds or leave it aloft unattended.



A variety of corona motors have been constructed in Jefimenko's laboratory. He has learned that their performance can be vastly improved by properly shaping the corona-producing electrodes [see illustration at right]. The working surface of the rotors should be made of a fairly thin plastic, such as Plexiglas or Mylar. Moreover, as I have mentioned, the inner surface of the cylinder should be backed by conducting foil to enhance the corona. Effective cylinders can be formed inexpensively out of plastic sewer pipe. Corona rotors can of course also be made in the form of disks.

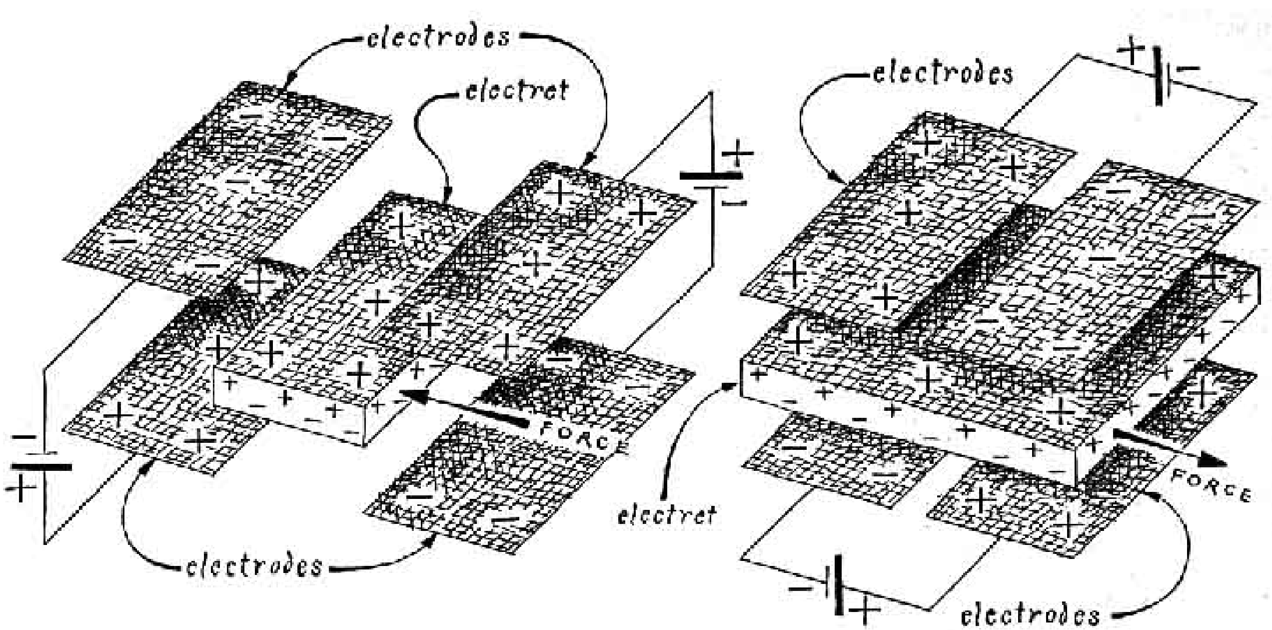
One model consists of a series of disks mounted on a common shaft. Double-edged electrodes placed radially between adjacent disks function much like Poggendorff's combs. This design needs no foil lining or backing because a potential gradient exists between electrodes on opposite sides of the disks. It is even possible to build a linear corona motor, a design that serves to achieve translational motion. A strip of plastic is placed between sets of knife-edge electrodes slanted to initiate motion in the desired direction.

Notwithstanding the problem of handling potentials on the order of a million volts without effective insulation materials, Jefimenko foresees the possibility of at least limited application of corona power machines. In The Physics Teacher (March, 1971) he and David K. Walker wrote: "These motors could be very useful for direct operation from high-voltage d.c. transmission lines as, for example, the 800 kV Pacific Northwest-Southwest Intertie, which is now being constructed between the Columbia River basin and California. It is conceivable that such motors could replace the complex installations now needed for converting the high-voltage d.c. to low-voltage a.c. All that would be required if corona motors were used for this purpose would be to operate local low-voltage a.c. generators from corona motors powered directly from the high-voltage d.c. line."

As Jefimenko points out, a limiting factor of the corona motor is its required minimum potential of 2,000 volts. This limitation is circumvented by a novel electrostatic motor invented in 1961 by a Russian physicist, A. N. Gubkin. The motor is based on an electret made in 1922 by Mototaro Eguchi, professor of physics at the Higher Naval College in Tokyo.

An electret is a sheet or slab of waxy dielectric material that supports an electric field, much as a permanent magnet carries a magnetic field. Strongly charged carnauba-wax electrets are available commercially, along with other electrostatic devices, from the Electret Scientific Company (P.O. Box4132, Star City, W.Va. 26505). A recipe for an effective electret material is 45 percent carnauba wax, 45 percent water-white rosin and 10 percent white beeswax. Some experimenters substitute Halowax for the rosin.

The ingredients are melted and left to cool to the solid phase in a direct-current electric field of several thousand volts. The wax continues to support the field even though the external source of potential is turned off [see "The Amateur Scientist, SCIENTIFIC AMERICAN, November, 1960, and July, 1968]. The electret reacts to neighboring charges exactly as though it were a charged electrode, that is, it is physically attracted or repelled depending on the polarity of the neighboring electrode.

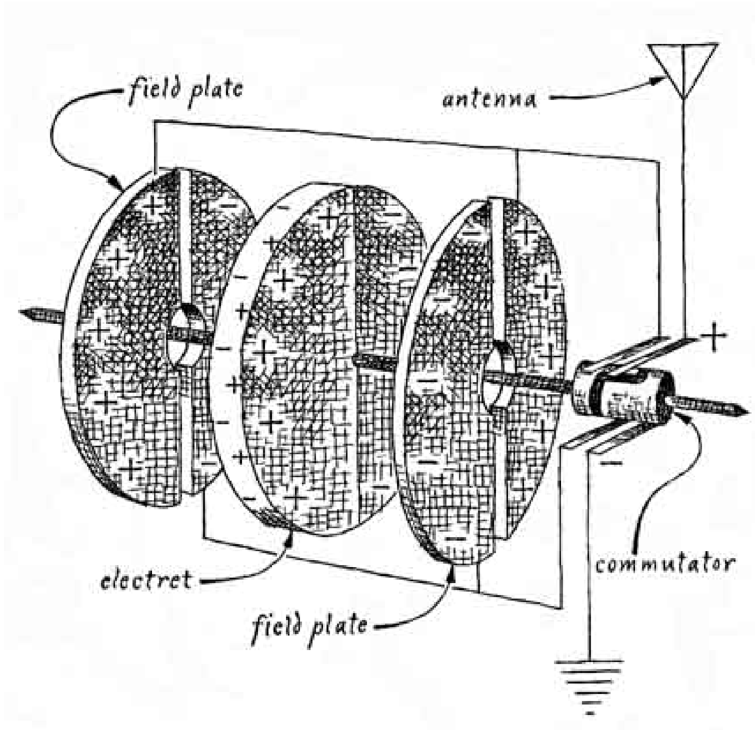


Gubkin harnessed this effect to make a motor. The rotor consisted of a pair of electrets in the shape of sectors supported at opposite ends of a shaft. The center of the shaft was supported transversely by an axle. When the rotor turned, the electrets were swept between adjacent pairs of charged metallic plates, which were also in the form of sectors.

The plates were electrified by an external source of power through the polarity-reversing switch known as a commutator. The commutator applied to the electrodes a charge of polarity opposite to the charge of the attracted electret. As the electret moved between the attracting plates, however, the commutator switched the plates to matching polarity. The alternate push and pull imparted momentum to the rotor in exact analogy to Franklin's motor.

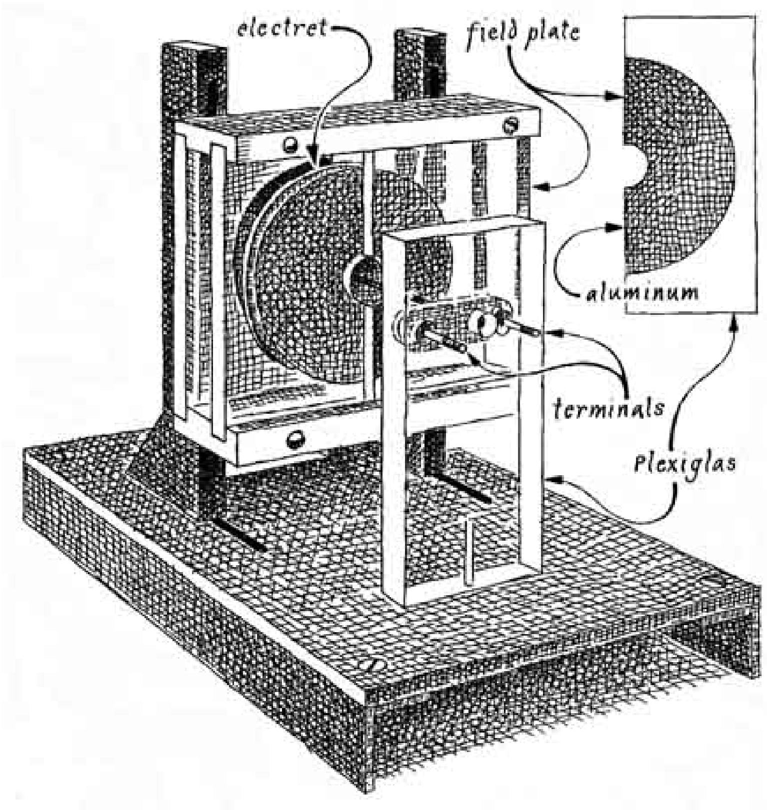
Gubkin's motor was deficient in two major respects. The distances between the electrodes and the electrets were needlessly large, so that the forces of attraction and repulsion were needlessly weak. Moreover, during the electret's transit between electrodes its surfaces were unshielded. Unshielded electrets attract neutralizing ions from the air and lose their

charge within hours or days.



Both inherent deficiencies of Gubkin's motor have been corrected in Jefimenko's laboratory by taking advantage of what is termed the slot effect. Instead of sandwiching the electret alternately between pairs of metal plates, Jefimenko employs opposing pairs of adjacent plates [see illustration at rightt]. The adjacent plates are separated by a narrow slot. When adjacent plates carry charges of opposite polarity, the electret experiences a force at right angles to the slot and in the plane of the electret. The strength of the force is at a maximum because the electret is close to the electrodes. Simultaneously the electrodes function as shields to prevent the neutralization of the electret by free ions.

Motors based on the slot effect can be designed in a number of forms. One design consists of an electret in the shape of a wafer-thin sheet of Mylar supported by a flat disk of balsa wood 100 millimeters in diameter and three millimeters thick. (A long-lasting charge is imparted to the Mylar by immersing it in a field of a few thousand volts from an electrostatic generator after the motor is assembled.) This rotor is sandwiched between four semicircular sectors that are cross-connected [see illustration].



The electret is mounted on a four-millimeter shaft of plastic that turns in jeweled bearings. The conducting surfaces of the commutator consist of dried India ink. The brushes are one-millimeter strips of kitchen aluminum foil. The motor operates on a few microwatts of power.

Jefimenko has demonstrated a similar motor that was designed to turn at a rate of about 60 revolutions per minute and develop a millionth of a horsepower on a 24-foot antenna having a small polonium probe at its upper end. (By emitting positive charges probes of this type tap the earth's field somewhat more efficiently than needle points do.) The performance of the motor easily met the design specifications. The charm of these motors lies in the fact that, although they do not accomplish very much, they can run forever.

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Oleg Jefimenko : Gravitation and Cogravitation -- Note de Lecture (PDF)
